

# THE INTELLIGENT OBJECT-ORIENTED INTERFACE IN THE DESIGN ENVIRONMENT OF THE CHARGED PARTICLES RELATIVISTIC BEAMS TRANSPORT CHANNELS

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## Abstract

The effectiveness of the design during the computer modeling is significantly determined by the user interface convenience of the application package and the time adaptation of the user to that application. This paper presents a new approach in the implementation of KATRAN software interface for the transport channels design of the charged particles relativistic beams. The interface is a sequence of operations for the designer during the virtual channel creation setting beam parameters at the channel input, the choice of the displayed elements of the channel, the channel assembly, setting the calculation algorithm with the parameters optimization. Thus the immersion of the designer into the details of the computing environment, the features of the software and channel modeling mathematical methods is not needed. The data objects are the typical elements of the transport channels (quadrupole lenses, magnets, open intervals, etc.). The work is carried out in interactive mode. After the "build and run" of the channel is finished, the full-screen multi-factor analysis of all major parameters of the beam and channel transparency is provided.

## INTRODUCTION

The channel configuration is determined by the dimensions of the accelerator hall and the experimental hall, as well as the requirements to the beam parameters and intensity [1-4]. Numerical modeling allows to identify the causes of loss of particles along the channel length and the "contribution" of each feed item in the total loss.

Adaptive modular approach to the design of channels is to pre-select separate focusing systems (modules). Preliminary optimization of the parameters of the modules based on the requirements as to the channel as a whole, and to individual modules. It defines the alignment of elements along the length of the module and the orientation of the lens (focusing-defocusing). Then, a parameter optimization of the whole channel in general. The channel calculation is performed using the software package "KATRAN" in MATLAB and Scilab.

The graphical tool environment allow you to display trajectories of individual particles, the envelopes and phase portraits of beam in horizontal and vertical plane. This information is enough to prompt the channel of the desired operation mode and adaptation of the entire focusing system to the requirements of the focusing of the beam.

The transport channel parameters

Particle dynamics in the transport channel is described by the transformation matrix in the quadrupoles, the magnets and the drifts in the horizontal  $m_{ij}$  and vertical

$n_{ij}$  plane. The relationship of the beam parameters (linear dimensions –  $x, z$  and divergence –  $x', z'$ ) at the output of channel (or individual element) with the input parameters is written as:

$$\begin{bmatrix} x_{out} \\ x'_{out} \end{bmatrix} = \begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{bmatrix} \begin{bmatrix} x_{in} \\ x'_{in} \end{bmatrix}, \dots, \begin{bmatrix} z_{out} \\ z'_{out} \end{bmatrix} = \begin{bmatrix} n_{11} & n_{12} \\ n_{21} & n_{22} \end{bmatrix} \begin{bmatrix} z_{in} \\ z'_{in} \end{bmatrix} \quad (1)$$

The elements of the matrices are functions of the geometric parameters of the channel and the values of the magnetic field in the quadrupole lenses and magnets. Thus, based on the values of matrix elements it is possible to form the target function  $F_t$ , which reflects the degree of achievement of the desired parameters of the beam in the plane of the experimental setup.

As an example, consider the modernization of the existing channel electron synchrotron (Fig. 1).

## THE OPTIMIZATION OF CHANNEL PARAMETERS

The optimization of transportation channels includes next basic premises:

- The length of the channel and location of the bending magnets remains unchanged (determined by existing premises).
- Only the values of the magnetic fields in the lenses and doublets and their location along the channel varied.

The channel is formed from three types of focusing systems.

There are three focus system types:

- Two single quadrupole lenses
- A doublet of quadrupole lenses
- A doublet of quadrupole lenses in combination with a rotary magnet

Requirements for the beam parameters from the experiment – may be a little linear and angular dimensions of the beam at the exit of the channel.

These two requirements are competing, using methods of extreme search allows you to obtain a compromise solution. Minimum linear size of the beam in both planes at the exit of the channel is ensured by the conditions stigmatically image  $m_{12} \rightarrow 0, n_{12} \rightarrow 0$  and about a single transformation  $m_{11} \rightarrow 1, n_{11} \rightarrow 1$ . The minimum divergence of the beam of electrons is mainly determined by the condition  $m_{21} \rightarrow 0, n_{21} \rightarrow 0$ .

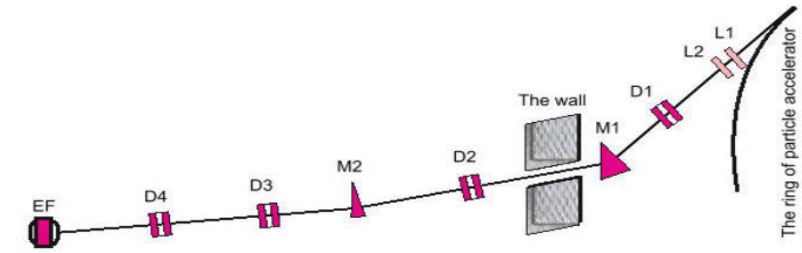


Figure 1: Scheme of the transport channel. L - quadrupole lense, D - doublet of quadrupole lenses, M - bending magnet, S - experimental installation.

The first step in the optimization of channel parameters is the choice of the schematic diagram of the position and orientation of the focusing elements along the length of the channel, which was carried out on the basis of the following provisions:

- The particle trajectories at the exit of the focusing system needs to be convergent and in between them an intermediate image of the electron beam.
- The output of the entire channel formed a stigmatic image of the electron beam.
- Linear sizes and the beam divergence at the channel outlet must be at the lowest.

A preliminary analysis of the individual modules allows more correctly generate the starting vector of the channel parameters, which are subject to optimization. As example, we present the analysis of the first focusing system (similar considered other systems of the channel).

THE FIRST SYSTEM

Range of values of the magnetic field in the lenses. Formed stigmatic image at system output (the conditions  $m_{12} \rightarrow 0, n_{12} \rightarrow 0$ ). The beam at the entrance of the transport channel has an elliptical cross-section, so that with the passage of the subsequent part of the channel ellipticity of the beam is not increased, the selected orientation of the lenses  $O D O F O$  (Fig.2). The criteria for assessing the quality of the focusing system are the values

of the transverse dimensions of the beam, which should not exceed the size of the diameter of vacuum based (Fig.3).

Table 1: The Parameters of the First Focusing System

The structure of the first system	Thick-ness (mg cm <sup>-2</sup> )	Compo-sition	Matrix channel	
			Horizontal plane	
Drift (m)	1.448	1.448	-0.63782	-0.00030
Magneti c field (kGs)	0.5	0.9577384	-1.001506	-1.56831
Drift (m)	0.81	0.81		
			Vertical plane	
			Magneti c field (kGs)	0.5
			0.7700728	-4.67739
Drift (m)	2.89	2.89	-1.47810	-0.21379

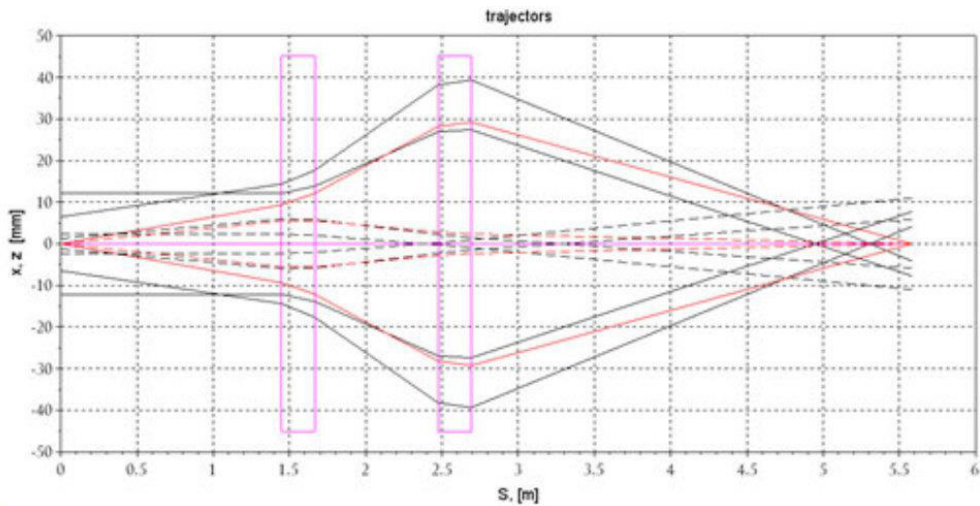


Figure 2: The particle trajectories in the horizontal (solid lines) and vertical plane (dashed line).

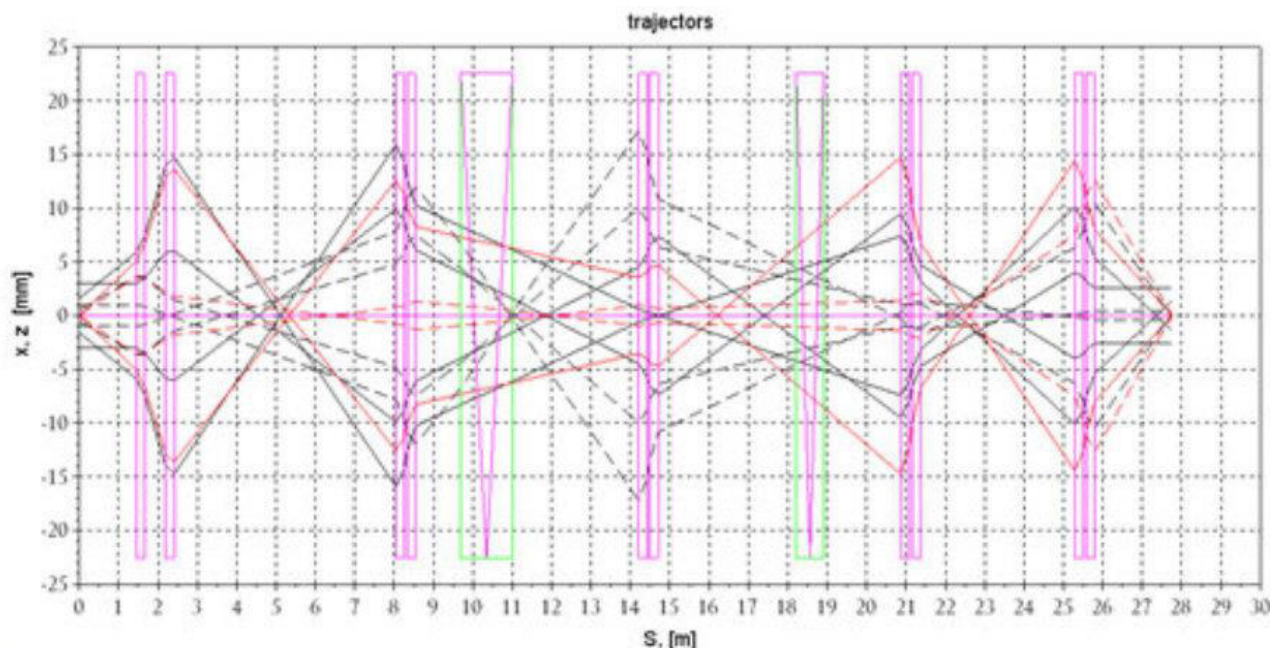


Figure 3: The particle trajectories in the horizontal (solid lines) and vertical plane (dashed line) channel as a whole.

Table 2: The Parameters of the First Focusing System

The elements of the channel	Channel structure	Length (m)	Field (kGs)
Drift		1.448	
Lens	L1(F)	0.217	1.0681174
Drift		0.532	
Lens	L2(D)	0.217	0.9053483
Drift		5.627	

As can be seen from the tables, after the optimization of channel parameters the parameters of the first focusing system (module) has undergone some correction overall.

Table 3: Matrix Transformation of the Transport channel

Horizontal plane	
0.8567355	0.0000082
0.0000067	1.1672214
Vertical plane	
-0.3863055	-0.0000569
-0.0000125	2.5886248

## CONCLUSION

The presented version of the environment is a continuation of earlier developments. The main advantages of this option are:

- The introduction of additional functions that extend the capabilities of study of the parameters of the transport channel and optimization of parameters;
- The accessibility to different hardware and software platforms;
- New simple multifunctional interface.

## REFERENCES

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